

**Calculation of
Central Valley Project Yield
For Section 3406 (b)(2) of the
Central Valley Project Improvement Act**

**U.S. Department of the Interior
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Executive Summary

The Central Valley Project (CVP) is a multipurpose water project that consists of a system of storage, conveyance, and power facilities to make multiple use of the water supplies developed and controlled by those facilities. The initial project authorization (1937) provided that the CVP “shall be used first, for river regulation, improvement of navigation, and flood control; second, for irrigation, and domestic uses; and third, for power” generation. The Central Valley Project Improvement Act (CVPIA) amends the previous authorizations of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes with equal priority to irrigation and domestic uses, and fish and wildlife enhancement as a project purpose equal to power generation.

The Central Valley Project Improvement Act defined Central Valley Project yield for purposes of Section 3406 (b)(2) (“(b)(2)”) as:

“the delivery capability of the Central Valley Project during the 1928-1934 drought period after fishery, water quality, and other flow and operational requirements imposed by terms and conditions existing in licenses, permits, and other agreements pertaining to the Central Valley Project under applicable State or Federal law existing at the time of enactment of this title have been met.”

Calculation of yield, in accordance with this definition and appropriate assumptions, has been accomplished and the results are summarized in this document. **That calculation shows that CVP yield, as defined in (b)(2), is 5,826,000 acre-feet per year.** That calculation assumes that delivery capability during the 1928-34 period is the average annual delivery to CVP users over that period. This definition does not include storage remaining in CVP reservoirs which has been recognized in some yield analyses as incremental supply. The yield is calculated at the projected 2020 level of development when CVP contractors could be expected to maximize use of the CVP supply available to them under their contracts without the CVPIA actions. The yield calculation, which shows the yield for five areas, is summarized below.

Area	Average Annual Deliveries 1928 to 1934 Period With Requirements in Effect on 10/30/92 (thousands of acre-feet/year)
Sacramento River Basin	2,059
American River Basin	670
Delta Division	2,154
Stanislaus River Basin	3
Friant Division	940
TOTAL	5,826

Introduction

The Central Valley Project (CVP) is a multipurpose water project that consists of a system of storage, conveyance, and power facilities to make multiple use of the water supplies developed and controlled by those facilities. The initial project authorization (1937) provided that the CVP “shall be used, first, for river regulation, improvement of navigation, and flood control; second, for irrigation, domestic uses; and third, for power” generation. The Central Valley Project Improvement Act (CVPIA) amends the previous authorizations of the CVP to include fish and wildlife protection, restoration, and mitigation as project purposes with equal priority to irrigation and domestic uses, and fish and wildlife enhancement as a project purpose equal to power generation.

The CVP has been developed to include 20 reservoirs with a combined storage capacity of more than 12 million acre-feet. The CVP also includes 8 powerplants, 2 pumping-generating plants, and approximately 500 miles of major canals. Figure 1 shows the location of the major CVP facilities. Waters included in the calculation of CVP yield for purposes of (b)(2), are diverted and stored in reservoirs on the Trinity, Sacramento, American, Stanislaus, San Joaquin Rivers, and in San Luis Reservoir. Table 1 lists the facilities included and not included in the (b)(2) yield calculation. CVP facilities that are not included in the (b)(2) yield calculation divert and store water on smaller tributaries to the Sacramento and American Rivers. Those facilities not relevant to the yield calculation either do not contribute to the yield (such as flood-control-only facilities) and/or are not hydrologically integrated into the operation of the CVP.

Historic CVP Yield

Historically, CVP yield was used as an index of water supply available through the operation of project facilities in accordance with entitlements under water rights permits and applicable laws, contracts, and agreements. Calculations of yield included a predefined set of deficiencies to CVP water contractors.

The historical definition of CVP Yield taken from the Bureau of Reclamation Mid-Pacific Region, “Central Valley Project Estimates of Yield”, dated September 1994 follows:

“the supply (subject in critically dry years to set percentages of supply reductions or deficiencies) that is available from the project under conditions that would be expected to occur under future levels of in-basin and project water demands (currently based on year 2020). Yield calculations are based on the critically dry hydrologic period that occurred in the Central Valley during 1928 through 1934. The calculation assumes a deficiency in water delivery totaling 100 percent of one year’s demand spread over this seven year period or approximately 25 percent in any one critically dry year.”

Applying this definition, CVP yield was calculated using monthly inflows and storage in CVP reservoirs to provide water for contractual obligations to be met by the CVP. Trinity, Shasta,

Folsom, Whiskeytown, and San Luis Reservoirs were operated in an integrated manner. Operations of these Reservoirs and CVP export facilities were then simulated to meet project obligations over the study period. Project obligations included flood control, instream flow requirements, in-basin uses, delta outflow needs, contractual commitments, and other existing operating agreements. Deficiency criteria as defined above were applied. After the 1976-1977 drought the 25% value in any one year was modified to be 50% in any one year with a seven year maximum of 100%.

Yield was the average annual (1928 through 1934) deliveries of the Sacramento River Basin, American River Basin, and Delta Division, plus the “incremental supply.” *(Incremental supply is the difference between the lowest cumulative storage in Shasta, Folsom, and Trinity Reservoirs that would occur during the 1928 through 1934 period and the minimum pool requirement (as defined in reservoir operating procedures). This difference was divided by the number of years it took to reach minimum reservoir storage during the 1928 through 1934 period.)*

For more details on traditional calculations see the “Central Valley Project Estimates of Yield,” Bureau of Reclamation Mid-Pacific Region, dated September 1994.

Definition of Yield for to the CVPIA Section 3406 (b)(2)

In contrast to the historical definition, the CVPIA defined CVP yield as:

“the delivery capability of the Central Valley Project during the 1928-1934 drought period after fishery, water quality, and other flow and operational requirements imposed by terms and conditions existing in licenses, permits, and other agreements pertaining to the Central Valley Project under applicable State or Federal law existing at the time of enactment of this title have been met.”

Given this definition, and appropriate assumptions, Reclamation has calculated CVP yield for the purposes of (b)(2). The calculation assumes that delivery capability during the 1928-34 period is the average annual deliveries to CVP users over that period. This definition does not include storage remaining in CVP reservoirs which has been recognized in some yield analyses as incremental supply.

Calculation of CVP Yield Pursuant to CVPIA Section 3406 (b)(2)

The assumptions used for this calculation of CVP yield for purposes of (b)(2) are generally consistent with the assumptions used in the Draft Programmatic Environmental Impact Statement (DPEIS) No Action Alternative for the CVPIA, released in November 1997, with the following key modifications:

- Sacramento-San Joaquin Delta water quality requirements were based on SWRCB D-1485 and D-1422 rather than the SWRCB 1995 Water Quality Control Plan.

- Full Contract amounts were assumed rather than the “historic maximum” used in the DPEIS.
- Allocation percentages to refuges were the same as allocations to CVP agricultural service contractors.

This yield calculation used both supply and demand based on the 2020 Hydrology, which is based on the projected 2020-level land use and demographics from DWR Bulletin 160-93. It was assumed CVP water contractors, maximum CVP use would be either contract amounts or demands in the DWR depletion analysis. This is consistent with historic yield calculations which were based on future level development. Modeling assumptions are described in detail in Appendix A. The model simulations were completed using an integrated suite of models consisting of PROSIM 99.0, SANJASM, STNMD99FSH.WK4, and WSTRN99.WK4. PROSIM 99.0 was released by Reclamation at a PROSIM Workshop on November 20, 1998. This version of the model includes a number of enhancements to the model logic and input hydrology to the version used in the DPEIS. Enhancements to the model are described in Appendix B.

Table 1 lists CVP facilities relevant to the determination of the (b)(2) yield as well as those not relevant. The facilities not relevant either do not contribute to the yield (such as flood-control-only facilities) or are not hydrologically integrated into the operation of the CVP. Based on the definition of “Central Valley Project” contained in the CVPIA, the Friant Division and Stanislaus River Basin have been included in this (b)(2) yield calculation. Since the operation of the Friant Division has a relationship to Reclamation’s responsibility for providing CVP water to the San Joaquin Exchange and Mendota Pool contractors, it was determined appropriate to include the yield of the Friant Division within the (b)(2) yield calculation. The operation of the Stanislaus River Basin relates to the ability of the CVP to comply with certain provisions of the 1995 Water Quality Control Plan and serves as an important fish and wildlife resource under CVPIA.

Applying these assumptions, hydrology and facilities, the models were then used to simulate the operation over the 1922 to 1990 period. Deliveries for contract years 1928 to 1934 were then extracted from the modeling results to determine the yield in accordance with (b)(2). The CVP contract amounts (including water right settlement agreements and historic refuge amounts which are not necessarily considered CVP “contracts”) and average annual deliveries over the 1928 to 1934 period are shown in Table 2. These results indicate that the yield for the CVP based on the definition in the statute and the assumptions included in this evaluation is 5,826,000 acre-feet. These models produce yield calculations based on numerous assumptions about hydrology, demands, and operational constraints and should not be considered as absolute values for yield. This yield calculation does not directly relate to any specific actual year and should not be used to predict actual deliveries for a given year. It is important to keep in perspective that planning models like PROSIM, SANJASM, and STNMD99FSH are best used in a comparative manner.

Figure 1
Major CVP Facilities

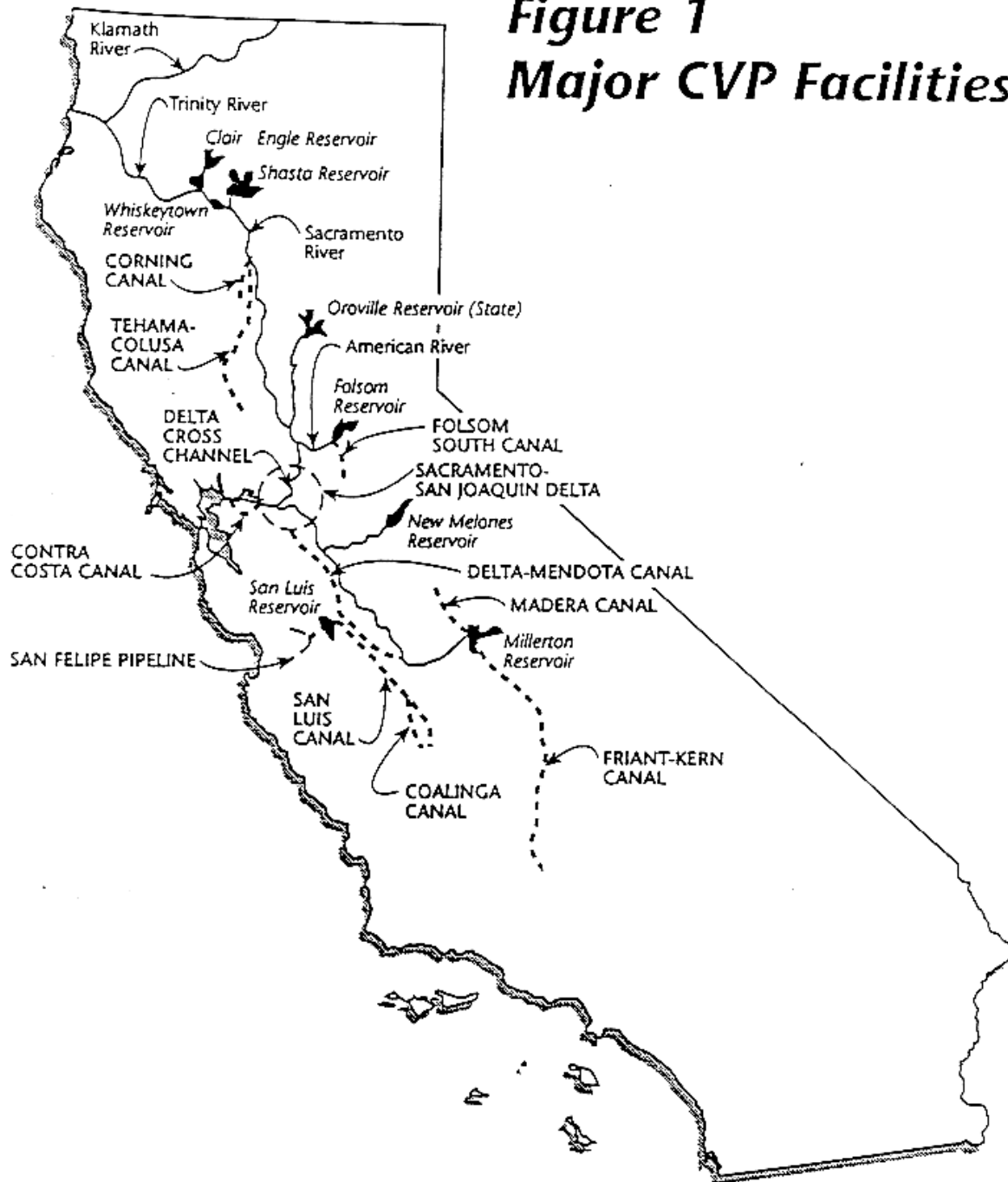


Table 1

CVP Facilities Included in CVPIA 3406 (b)(2) Yield Calculation			
Dams	Reservoir Capacity (Acre-Feet)	Canals & Conduits	Initial Capacity (cfs)
Shasta	4,552,000	Delta Cross Channel	3,500
Trinity	2,447,000	Delta-Mendota	4,600
New Melones	2,400,000	Contra-Costa	350
San Luis (CVP portion)	974,000	Corning	500
Folsom	975,000	San Luis (CVP portion)	6,000
Friant	521,000	Coalinga	1,100
Whiskeytown	240,000	Tehama-Colusa	2,530
O'Neill Forebay	57,000	Folsom-South	3,500
Keswick	24,000	Clear Creek Aqueduct	73
Lewiston	15,000	Cow Creek Aqueduct	92
Nimbus	9,000	Clear Creek Tunnel	3,600
Spring Creek	6,000	Spring Creek Tunnel	4,200
Red Bluff Diversion	-	Pacheco Tunnel	670
Contra Loma	2,000	Friant-Kern	4,000
		Madera	1,000
Facilities Not Included in CVPIA 3406 (b)(2) Yield Calculation			
Dams	Reservoir Capacity (Acre-Feet)	Canals & Conduits	Initial Capacity (cfs)
Sly Park	41,000	Camino	125
Black Butte	160,000	Forest Hill	25
Camp Creek Diversion	-	Camp Creek Tunnel	500
Franchi Diversion	-		
Little Panoche Detention	6,000		
Los Banos Detention	35,000		
Hidden	90,000		
Buchanan	110,000		
Sugar Pine	16,500		

Table 2
CVP Contract Amounts and Average Annual Deliveries 1928 to 1934

Water Users	Cont Amt TAF/YR	Avg Del TAF/YR	Comments
Sacramento River Basin			
Settlement	2,217	1,908	Includes cities of Redding & W. Sac
Agricultural	394	119	
M&I	6	5	Redding/Buckeye included above
Refuge	<u>92</u>	<u>27</u>	Historic Level 2 - Sacto Complex
Subtotal	2,709	2,059	
American River Basin			
Water Rights	526	520	
Agricultural	92	25	Includes PCWA 92 TAF/YR
M&I	<u>286</u>	<u>125</u>	Includes PCWA 25 TAF/YR & EBMUD
Subtotal	904	670	
Delta Division			
Contra Costa	195	150	Maximum delivery 175 TAF/YR
Exchange/Mendot	885	761	Includes Fresno Slough Schedule II
DMC Agricultural	526	278	
DMC Refuge	147	78	Historic Level 2
San Felipe AG	89	47	Includes Pajaro Valley 19.9 TAF/YR
San Felipe M&I	128	110	
San Luis AG	1,237	644	
San Luis M&I	17	15	Some M&I for San Luis & Panoche WDs
Cross Valley	128	65	
South San Joaquin	<u>10</u>	<u>6</u>	Historic Level 2 - Kern NWR only
Subtotal	3,362	2,154	
Stanislaus River Basin			
CVP Firm Water	49	3	Long term contract for firm water
CVP Interim	<u>106</u>	<u>0</u>	Based on build-up of In-Basin demands
Subtotal	155	3	
Friant Division			
Class I	800	751	Long term contract for firm water
Class II	<u>1,400</u>	<u>189</u>	Supply based on hydrologic conditions
Subtotal	2,200	940	
GRAND TOTAL	9,330	5,826	

APPENDIX A

MODELING ASSUMPTIONS FOR A PRE-CVPIA CONDITIONS YIELD RUN

OBJECTIVE

The objective of this study was to determine the average annual delivery capability for the March 1928 through February 1935 period while meeting the system requirements as of October 30, 1992, which is being used to represent yield pursuant to the (b)(2).

METHODOLOGY

The operation of the system's reservoirs was simulated based on balancing priorities considering multiple conflicting goals and constraints. The foremost consideration was flood control, and Reclamation Safety of Dams, followed by minimum instream flow requirements, including Delta outflow, required in-basin demands, and water right settlement demands. Next, storage retention for temperature control was considered (where appropriate), followed by water supply for M&I demands, agricultural, and refuge demands.

This study was completed using PROSIM, SANJASM, WSTRN99.WK4 and STNMD99FSH.WK4. DMC deliveries from PROSIM were input to WSTRN99 to develop westside return flows to the San Joaquin River. These westside return flows and PROSIM deliveries to Mendota Pool were input to SANJASM. Flow and quality on the San Joaquin River above the Stanislaus from SANJASM were input to STNMD99FSH. The resulting Vernalis flows were output from STNMD99FSH as a time series for input to PROSIM. The suite of models was iterated until there were no significant changes in DMC deliveries and Vernalis flows.

PROSIM

PROSIM version 99.0, described in Appendix B, and 20B2_015.MCF data set was used in this study.

Hydrology and Demands

- The State of California's Department of Water Resources (DWR) Bulletin 160-93 hydrologic data set HYD-C-09A was used. This data reflects the historic hydrology superimposed on an assumed constant projected level -- in this case, the year 2020. The building blocks of this data (Consumptive Use and Depletion Analyses data for HYD-C-09A) were organized into the required format for PROSIM.
- Eastside Streams - Pre-Operated: A time series of monthly flows representing the combined net inflow to the Delta from the Cosumnes, Mokelumne and Calaveras rivers was taken from SANJASM output used in the Draft PEIS Cumulative Impacts Study (study 1d). See Draft PEIS documentation, Technical Appendix Volume 7 for additional details. Refer to the SANJASM section for further details.
- San Joaquin River - Vernalis flows from STNMD99FSH are input as a time series. Refer to the SANJASM section for further details.

- CVP demands - Full Contractual amounts for contracts in effect as of October 1992 were used. Demands include:
 - 1) Refuge Water Supply at historical "Level II" without losses.
 - 2) A Pajaro Valley demand of 19.9 TAF/YR for San Felipe Project.
 - 3) No interim water supplies.
- Delta Consumptive Use : The gross consumptive use and Delta precipitation from DWR's hydrology were used.
- State Water Project export demands: The variable annual demand (3.4 - 4.2 MAF based on the Southern California Wetness Index) and the monthly pattern were taken from DWRSIM run 514. No inclusion of interruptible demands.

PHYSICAL FACILITIES

Reservoirs

PROSIM simulated the operation of the reservoirs listed in the table below. The southern SWP reservoirs of Pyramid, Castaic, Silverwood and Perris Lakes were represented by two aggregated storage facilities, East Branch Reservoir and West Branch Reservoir. The reservoir characteristics are shown below:

RESERVOIR NAME	Maximum Possible Storage (TAF)	Maximum Power Release (CFS)
Clair Engle	2447	3300 ¹
Whiskeytown	240	Not Used
Shasta	4552	Varied
Oroville	3538	Not Used
Folsom	974	5000 ²
CVP San Luis	972	Not Used
SWP San Luis	1067	Not Used
East Branch	200	Not Used
West Branch	489	Not Used

¹ This limitation is actually based on Carr Power Plant's turbine capacity, not Trinity Dam's turbine capacity. Further, in this study, the hydraulic capacity was assumed to remain constant regardless of Whiskeytown's storage.

² This limitation is actually based on Nimbus Power Plant turbine capacity, not Folsom Dam's turbine capacity.

Delta Export Pumping Plants Physical and/or Regulatory Limits

(CFS)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Tracy ¹	4600	4600	4600	4600	4600	4600	4600	3000 ²	3000 ²	4600	4600	4600
Banks	6680	6680	7590 ⁴	8500 ⁴	8500 ⁴	7590 ⁴	6680	3000 ³	3000 ³	4600 ²	6680	6680

¹ These limits frequently go unrealized due to the DMC capacity reductions shortly downstream of the pumps (4300 cfs @ DMC Mile Post 20.62 and 4200 cfs @ DMC Mile Post 33.71).

² SWRCB's D-1485 criteria for striped bass survival. Additional pumping of federal water by the State called "wheeling" occurs later in the year to make up for these restrictions.

³ SWRCB's D-1485 criteria for striped bass survival. In addition, pumping is restricted further (to 2000 cfs) if storage withdrawals from Oroville are being made - per January 5, 1987 interim agreement between California's Department of Fish and Game (DFG) and California's Department of Water Resources (DWR).

⁴ Pumping at Banks between Dec 15 and March 15 may be augmented above the 6680 up to the limits listed depending upon flow in San Joaquin River at Vernalis per the Corps' October 13, 1981 Public Notice criteria. A maximum of 8500 cfs is assumed based on hydraulic constraints surrounding the pumps. South Delta improvements which would allow the full 11 pumps' capacity of 10,300 cfs to be realized are assumed not to be in place.

MINIMUM FLOW CRITERIA ASSUMED

Trinity River Basin

340 TAF/YR fishery flow volume per year - Interim Secretarial Decision of 1991

(CFS)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
	300	300	300	300	300	300	300	1591	578	450	450	450

Clear Creek Basin

This is per Reclamation operating policy, based largely on a Memorandum dated May 3 1967, from the National Park Service to Reclamation, which in turn is based on the Agreement dated March 31, 1960 between DFG and Reclamation.

(CFS)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Normal	50	100	100	50	50	50	50	50	50	50	50	50
Critical	50	70	70	50	50	50	50	50	50	50	50	50

Upper Sacramento River

Minimum flows and temperature control objectives are consistent with general operations to meet requirements of the Winter-Run Chinook Salmon Biological Opinion issued by the National Marine Fisheries Service (NMFS) in October 1992. Reclamation must maintain *daily* average water temperature in the Sacramento River at no more than 56° F within the winter-run chinook salmon spawning grounds below Keswick Dam. It is not possible, however, to simulate temperature criteria in the PROSIM model. Instead PROSIM includes criteria consistent with temperature control objectives and those results are evaluated for their general compliance to temperature control goals. To that end the PROSIM contains the following flow criteria and minimum year end storage criteria.

(CFS)	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Normal	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250	3250
Critical	3000	3000	3000	3000	3000	3000	3000	3250	3250	3250	3250	3000

Reclamation must maintain a minimum end-of-water-year (September 30) carryover storage in Shasta Reservoir of 1.9 MAF. NMFS recognizes that it may not be possible to maintain a minimum carryover storage of 1.9 MAF in the driest 10 percent of water year types. This PROSIM model simulation is checked to ensure that this storage criteria is met.

Lower Sacramento River

Wilkins Slough/Navigation Control Point Objective - This objective balances the relationship of river stages and diversion structures along the Sacramento River with the need for conservation of storage at Shasta Reservoir for temperature control purposes. Generally, the objective varies between 5000 cfs for good hydrologic and storage conditions and 4000 cfs for moderate hydrologic and storage conditions. In years of poor hydrologic and storage conditions, (i.e., years in which NMFS would require re-consultation for temperature control objectives) the Wilkins Slough objective is modeled to allow dropping of flows to 3500 cfs to help conserve storage at Shasta Reservoir.

American River Basin

The Lower American River minimum flows were between 250 cfs (D-893, Folsom Dam water right decision) and 3000 cfs (flows mandated by Judge Hodge for EBMUD to receive deliveries from the American River). This criteria is known informally as “Modified D-1400.” (D-1400 is the Decision regarding Auburn Dam.) For modeling, the criteria that were used were between 3000 cfs when water availability is good and 250 cfs when water availability is very poor, based on a combination of Folsom storage and hydrologic conditions.

The Hodge Decision determined when EBMUD receives water during the years when court-mandated minimum flows are met. EBMUD receives water to a maximum of 150 TAF/YR.

DELTA CRITERIA

D-1485 Water Quality Standards and 1986 COA framework between the CVP and SWP for implementing those standards on a coordinated basis. The COA defines the sharing of the water supplies and responsibilities in the Delta on a conditional and formula basis. When the Delta is in a surplus condition, no sharing is required. When the Delta is being supported by unregulated flow, the available water is shared on a 55% CVP 45% SWP basis. When the Delta requires storage withdrawals to support Delta standards then the responsibility is shared on a 75% CVP 25% SWP basis.

The Delta Cross Channel Gates were modeled as closed February through April per the 1992 and 1993 Winter-Run Chinook Salmon Biological Opinions.

WHEELING

Three quantities of water were possibly assumed to be transported by the State for the Federal government. A description of these is given below:

D-1485 Wheeling

This CVP water is exported from the Delta by Banks pumping plant each year as compensation for the pumping restrictions placed on Tracy pumping plant in May and June per SWRCB's Decision 1485. The following assumptions were made:

- Wheeling (payback) was assumed to occur within the July - November time frame.
- Up to 194 TAF could be moved in a single month.
- Whether Tracy was pumping at its maximum permissible rate during May and June was not considered.
- D-1485 wheeling was not required if the CVP simulation imposed a deficiency level greater than 19 (Ag 10% delivery).
- Wheeling was done to the extent needed to fill CVP share of San Luis Reservoir to its rule curve.
- Wheeling was only done to the extent the SWP had available capacity at Banks, i.e., SWP was not forced to wheel all 194 TAF each calendar year.
- CVP excess in the Delta was labeled wheeling water to the extent possible.

Cross Valley Wheeling

This CVP water (up to 128 TAF/YR) is exported and banked in the SWP share of San Luis Reservoir as necessary to satisfy CVP contractor demand (Cross Valley water) from the California Aqueduct.

Refuge Wheeling

This scenario included additional wheeling for Kern National Wildlife Refuge.

ALLOCATION GUIDELINES

Reclamation guidelines set minimum CVP deliveries to M&I Water Service Contractors at 75 percent of the historic use (which is generally assumed to be equivalent to the contract amount at the 2020 level). The allocation guidelines for Sacramento River Water Rights and San Joaquin River Exchange Contractors are 75 percent of the full contract amount based on the Shasta Index. CVP minimum water deliveries to Agricultural Water Service Contractors can go as low as zero percent of the full contract amount. Refuge allocations are assumed the same as Agricultural Water Service Contractors. Reductions to allocations do not necessarily equal the lowest allocation allowed but are based on a combination of available reservoir storage and projected runoff. In addition, Reclamation may make additional allocations for drought mitigation for the Refuges and hardship water for Agricultural and M&I users on a case by case basis which is not modeled.

CVP MINIMUM ALLOCATIONS

Water User	Minimum Allocation Guidelines used in CVP Yield Calculation
Sacramento River Water Rights and San Joaquin River Exchange Contractors	75% based on Shasta Criteria
Agricultural Water Service	0% per Contract
M&I Water Service	75% per Historical Use
Refuges	Same as Agricultural Water Service

VARIABLE STATE WATER PROJECT (SWP) DEMANDS

PROSIM 99.0 incorporates variable water demands for SWP entitlement holders south of the Delta. DWR developed these demands for its monthly SWP/CVP simulation model (DWRSIM) and demands vary based on precipitation levels south of the Delta. These revised demands are more representative of actual SWP operations than the constant annual demands assumed in the Draft PEIS PROSIM analyses. In the Draft PEIS, the constant annual demands were 4.2 million acre-feet. The revised annual demands range from 3.4 to 4.2 million acre-feet.

SANJASM

SANJASM version 3.61x was run with the BASE_IT1.MCF data set.

Hydrology and Demands

- ! The input hydrology for SANJASM is based on historical records modified for projected level conditions. The inflows were based on DWR's Bulletin 160-93 projected changes in upstream consumptive use.
- ! Demand levels for the Middle San Joaquin River, Merced River, and Tuolumne River are assumed to be the same as recent historic because these streams are fully developed.
- ! Demands on the Stanislaus River were balanced to provide equitable allocations to each interest. This river is seriously over-allocated and it is not possible to fully meet each requirement.
- ! Demands on the Calaveras River and Mokelumne River are based on projections of 2020 water use by SEWD and EBMUD. The Cosumnes River inflow is modified to allow for increased demand from Jenkinson Lake by El Dorado County.
- ! Westside Return flows are based on historical "Level II" without losses.

PHYSICAL FACILITIES

Reservoirs

SANJASM simulates the operation of the reservoirs listed in the table below.

RESERVOIR NAME	Maximum Possible Storage (TAF)
Friant	521
Hidden	90
Buchanan	151
New Exchequer	1024
New Don Pedro	1900
Modesto	29
Turlock	45
New Melones	2420
Tulloch	67

RESERVOIR NAME	Maximum Possible Storage (TAF)
New Hogan	325
Pardee	210
Camanche	431

Canals

SANJASM simulates exports through Friant-Kern Canal, Madera Canal and East Bay Aqueduct.

MINIMUM FLOW CRITERIA

Middle San Joaquin River

A minimum flow of 5 cfs is maintained in the reach between Friant Dam and Gravelly Ford to ensure adequate flow levels for the riparian users in this reach.

Fresno River

No minimum instream flow requirement.

Chowchilla River

No minimum instream flow requirement.

Merced River

Instream flows are defined by the FERC license agreement and the Davis-Grunsky agreement. Flows range from 85 TAF to 68 TAF dependent upon year type.

Tuolumne River

Instream flows are defined by the original FERC license agreement. Flows range from 169.4 TAF to 66 TAF dependent upon year type.

Stanislaus River

Simulated in STNMD99FSH.WK4.

Calaveras River

No minimum instream flow requirement.

Mokelumne River

Instream flows are based on EBMUD's proposed Lower Mokelumne River Plan (LMRP) and range from 113.7 TAF to 18.7 TAF depending on year type.

Cosumnes River

No minimum instream flow requirement.

ALLOCATION GUIDELINES

Demand allocations are handled differently for each river in the San Joaquin Basin. Each stream is modeled based on operating criteria provided by the responsible entities or on recent historical delivery patterns.

Middle San Joaquin River

Exports to the Friant-Kern and Madera Canals are based on linear regressions which were developed against recent historic (1968 - 1990) deliveries. These exports utilize almost the entire inflow to the reservoir with the exception of flood spills and releases for riparian demands downstream. Releases for riparian diverters between Friant Dam and Gravelly Ford are based on historic patterns.

Fresno and Chowchilla Rivers

Deliveries are based on recent historic delivery patterns. Deficiencies are taken based on water year type. The maximum deficiency is 50% for critical years.

Merced River

Maximum demand is based on testimony provided during the D-1630 hearings. Deficiencies are taken based on water year type. The maximum deficiency is 40% for critical years.

Tuolumne River

Deliveries are based on recent historic delivery patterns. Deficiencies are taken based on water year type. The maximum deficiency is 40% for critical years.

Stanislaus River

For this study, the Stanislaus River was simulated in STNMD99FSH.

Calaveras River

Demand levels were provided by SEWD. Deficiencies on the Calaveras River are computed on an iterative basis, with the deficiency level being determined by the desired carryover storage level.

Mokelumne River

EBMUD contracts contain deficiency criteria is based on projected end of year total system storage. Each contract contains different criteria and is modeled independently in SANJASM. The maximum deficiencies taken vary by contract and range from 15 % to 60%.

STNMD99FSH.WK4

STNMD99FSH is a variation of Reclamation's STANMOD spreadsheet. This version allows the 1987 DFG agreement (98.3-302 TAF/YR) to be modeled with a variant to allow instream flows to be reduced to 69 TAF/YR under certain criteria. This spreadsheet takes as input the flow and water quality at Maze Rd, just upstream of the Stanislaus River on the mainstem San Joaquin River, as modeled in SANJASM. It then simulates the Stanislaus River from New Melones Reservoir to the confluence of the San Joaquin River, and on down to Vernalis. Output from STNMD99FSH includes flow and water quality at Vernalis, as well as resulting Stanislaus River operations.

Stanislaus River Basin

There is inadequate supply in the Stanislaus Basin to meet all of the contracts, permits, agreements and standards which apply during an extended dry period. The 1987 Agreement between USBR and DFG (1987 Fish Agreement) and the D-1422 Water Quality standards are assumed to have equal priority. The assumptions used in the STNMD99FSH are discussed below:

- For this modeling only, the 1987 Agreement between USBR and DFG outlining a minimum fishery flow volume of 98.3 - 302 TAF/YR is modified to use 69 TAF/YR in years when the Water Quality Standard is relaxed (see next bullet). Instream flows are not increased above 98.3 TAF/YR until all other requirements (Water Quality, CVP contracts, Dissolved Oxygen) are met in full.
- D-1422 Water Quality Standard of 500 mg/l TDS throughout the year at Vernalis was modified to be 500 mg/l TDS from April through September and 600 mg/l TDS from October through March in years where the end of February storage plus the March through September forecasted inflow is less than 1.7 MAF. The modified standards during the extremely dry years is consistent with historical operations during the 1987-1992 drought.
- The modified water quality standards are relaxed by a factor ranging from 1.2 to 1.11 during these same years. To obtain the modified standards two model runs were made. The first run contained the 1995 inflows. This run determined the Vernalis water quality relaxation factors and the associated CVP deliveries. A second run with 2020 inflows used the same Vernalis water quality relaxation factors and reduced the CVP contract water deliveries to obtain the same minimum storage level in New Melones reservoir as the 1995 run.

- Ripon Dissolved Oxygen (D.O.) requirement of 7.0 mg/l on a daily basis in the Stanislaus Basin Plan is modeled using a minimum flow of 222 cfs in June, 264 cfs in July, 267 cfs in August and 240 cfs in September. These flow criteria were extrapolated from historic 1995 operation records. In 1995, it was only necessary to release water quality water for Ripon D.O.; this provides a good estimate of the flow needed to meet the D.O. requirement.
- Deliveries to the Oakdale/South San Joaquin Irrigation Districts (water rights settlement contractors) are made based on the formula contained in the 1988 Water Rights Settlement Agreement. This settlement allows for deliveries of 600 TAF/YR in years when inflow to New Melones is greater than 600 TAF/YR. Reductions are taken based on the formula when the inflow to New Melones drops below 600 TAF/YR.
- CVP contract allocations are based on February end of month storage plus forecasted inflow. When the Water Quality requirements at Vernalis are relaxed and the instream flow allocation is 69 TAF/YR, then CVP contractors do not receive any water. The CVP contracts are set at a maximum of 155 TAF/YR for the 1995 level run to determine the Vernalis Water Quality relaxation factors for the dry years. The 2020 run used inflows to New Melones from DWR Bulletin 160-93, which are 6 TAF/YR less than the 1995 level. This reduced inflow was assumed to be consumptively used by upstream users who are not necessarily CVP contractors. The interim CVP contracts were reduced by 6 TAF/YR for the final 2020 run, to adjust for the decrease in inflow. CVP contractors receive 149 TAF/YR in all years when instream flow receives 302 TAF/YR. In all other years, allocations to CVP Contractors range between 0 and 149 TAF/YR.
- Goodwin releases were limited to 1250 cfs based on the 1987 Department of Fish and Game Agreement, except during flood control operations.

WSTRN99.WK4

This is a spreadsheet data pre-processor for SANJASM. It takes the DMC deliveries from PROSIM, allocates them to SANJASM nodes, and computes return flow quantities for each node. The resulting data file is input to SANJASM along with the DMC deliveries for PROSIM nodes 48 + 54 (Mendota Pool deliveries).

APPENDIX B

The PROSIM analysis for the estimation of CVP Yield was conducted with the most recent version of PROSIM, referred to as PROSIM 99.0, released by Reclamation in November 1998. This appendix presents the enhancements incorporated into the PROSIM 99.0 model by Reclamation and the U.S. Fish and Wildlife Service (Service), as compared to an older version of the model that was used to perform the Draft PEIS analyses. The surface water modeling conducted for the Draft PEIS, which was the basis for the information used in the yield study, used Reclamation's PROSIM model version 5.49 with some additional modifications specific to the Draft PEIS alternatives (Modified PROSIM 5.49). All of the Draft PEIS alternatives were evaluated at a future level of development using projected hydrology based on DWR Bulletin 160-93.

In comparison to Modified PROSIM 5.49, PROSIM 99.0 includes the following enhancements:

- A correction for the inconsistency in the input hydrology associated with the use of theoretical storage
- A revised nodal configuration
- Improved coordination of Trinity and Shasta Division operations
- Updated logic for implementation of 3406(b)(2) water management actions
- Other corrections to the input hydrology.

These enhancements provide a more refined estimate of the available water supply and a better characterization of CVP operations. The net cumulative effect of the hydrology corrections is a general reduction in the estimated average annual water supply available in the Sacramento Valley with more prevalent reductions in drier years.

A detailed presentation of the modifications incorporated into PROSIM 99.0 was presented by Reclamation at a public workshop on November 20, 1998. A brief summary of the major model logic and input hydrology improvements incorporated into PROSIM 99.0 as presented at the workshop are provided in the following sections.

PROSIM 99.0 MODEL ENHANCEMENTS

This section summarizes the major code and model logic improvements, input hydrology corrections, and other enhancements included in PROSIM 99.0, as compared to Modified PROSIM 5.49.

CODE AND MODEL LOGIC ENHANCEMENTS

Code and model logic changes include a correction for the inconsistency associated with the use of theoretical storage as well as other improvements to allow PROSIM 99.0 to better characterize CVP operations.

Theoretical Storage Operations

As part of the development of PROSIM 99.0, Reclamation modified the model logic and input hydrology to eliminate the inconsistency discovered in the use of theoretical storage. Withdrawals from theoretical storage generally represent additional groundwater pumping, above historic levels, that would occur at future levels of development due to increased water demand or reductions in available surface water supplies. Modified PROSIM 5.49 used a pre-operated time series of monthly values derived from the DWR Depletion Analysis Model. As described in the PROSIM M/M Technical Appendix to the DPEIS, the Depletion Analysis Model provides the basic hydrologic data that is used to develop the PROSIM input hydrology. The addition of this withdrawal time series to Modified PROSIM 5.49 gains was inconsistent with the logic used within PROSIM to allocate CVP surface water supplies to Sacramento Valley CVP Contractors.

In PROSIM, water deliveries to Sacramento Valley CVP Contractors are composed of available Sacramento River flow, local gains, and releases from CVP reservoir storage. The addition of the withdrawals from theoretical storage to the gains caused PROSIM to incorrectly credit for withdrawals as part of available CVP surface water supplies, thereby reducing the amount of water that needed to be released from Shasta Lake to meet contractor demands. This inconsistency occurred primarily in drier years when the Depletion Analysis had utilized withdrawals from theoretical storage to supplement limited surface water supplies.

To correct the inconsistency, Reclamation removed the withdrawals from theoretical storage from the gains and developed new model logic that includes a dynamic monthly calculation of withdrawals from, and recharge of, theoretical storage. This new logic is consistent with the DWR methodology for calculating withdrawals from, and recharge of, theoretical storage and is consistent with CVP allocation guidelines for deliveries to Sacramento Valley CVP Contractors. As compared to Modified PROSIM 5.49, these PROSIM 99.0 corrections do not change the amount of water delivered to CVP Sacramento River Water Rights Contractors, but do increase releases from Shasta Lake in drier years to meet these contract obligations. As a result, there may be less CVP reservoir storage available to meet other CVP operational objectives, including deliveries to water service contractors.

Revised Node Configuration

To better characterize the locations of the major agricultural diversions within the Sacramento River Basin, six additional nodes were added to PROSIM 99.0. A model node represents a physical location where accumulated gains, losses, diversions, and return flows are accounted. Descriptions of the locations of the additional nodes, including corresponding Modified PROSIM 5.49 node numbers and associated DWR Depletion Areas (DA), are presented in Table B-1. Figure B-1 shows a schematic of the PROSIM 99.0 node configuration.

TABLE B-1**ADDITIONAL PROSIM 99.0 NODES**

PROSIM 99.0 Node Number	Modified PROSIM 5.49 Node Number	Associated DWR DA Number	Description of Node Location
4	4	62	Shasta Lake
66	4		Keswick Dam
61	5	58	DA58 Diversions
62	5		Confluence of Sacramento River and Clear Creek
5	5		Red Bluff Diversion Dam
9	9	12	Tehama-Colusa Canal and Associated Diversions
67	9	12	Glenn-Colusa Canal and Associated Diversions
59	9	12	Provident/Princeton-Codora-Glenn/Maxwell Diversions
60	9	12	Colusa Basin Drain

Trinity - Shasta Division Operations

To better characterize the coordinated operation of the Trinity and Shasta Divisions of the CVP, Reclamation developed a new storage-diversion relationship to determine the amount of water to divert from the Trinity River Basin to the Sacramento River. This storage-diversion relationship accounts for both Shasta and Clair Engle Lake storage levels when determining the minimum amount of water to be diverted in a given month. The relationship in Modified PROSIM 5.49 accounted for Clair Engle Lake storage only. The minimum monthly and seasonal diversion targets used in this new relationship were developed by Reclamation based on current Trinity-Shasta Division operations.

INPUT HYDROLOGY ENHANCEMENTS

In addition to modifications to the PROSIM model logic, Reclamation also incorporated a number of improvements associated with the model input hydrology. These improvements allow better characterization of the projected future available water supply in the American and Feather River Basins. Following is a brief discussion of the hydrology modifications.

American River

Two modifications were made to the PROSIM input hydrology associated with the American River. The first change included revised estimates for losses to groundwater along the lower American River. In the Draft PEIS, annual losses were assumed to be 42,000 acre-feet per year and were incorporated as a twelve month repeating pattern. PROSIM 99.0 includes a time series of monthly seepage losses developed as part of the American River Water Resources Investigation (ARWRI). The use of the time series increases average annual losses to groundwater to about 130,000 acre-feet per year.

The City of Sacramento is located in DA 59, but it is included in DWR's calculation of DA 70 historic depletion. To be consistent with DWR accounting, the second change corrected double counting of historic City of Sacramento exports in the original DA 70 PROSIM input hydrology. As a result, the revised DA 70 water supply is reduced by about 48,000 acre-feet on an average annual basis.

Feather River

Two corrections were made to the input hydrology associated with the Feather River. The first change corrected double counting of inflow from Kelly Ridge, downstream of Lake Oroville, by modifying the DA 69 water supply calculations. This reduced available water supply in the Feather River Basin by about 70,000 acre-feet on an average annual basis. Secondly, the location of return flows from Feather River diversions were adjusted to be consistent with DWR assumptions in the DWRSIM planning model. In the Draft PEIS, return flows were located at downstream nodes on the Feather River. In PROSIM 99.0, return flows are located on the Sacramento River below Verona.

FIGURE B-1

